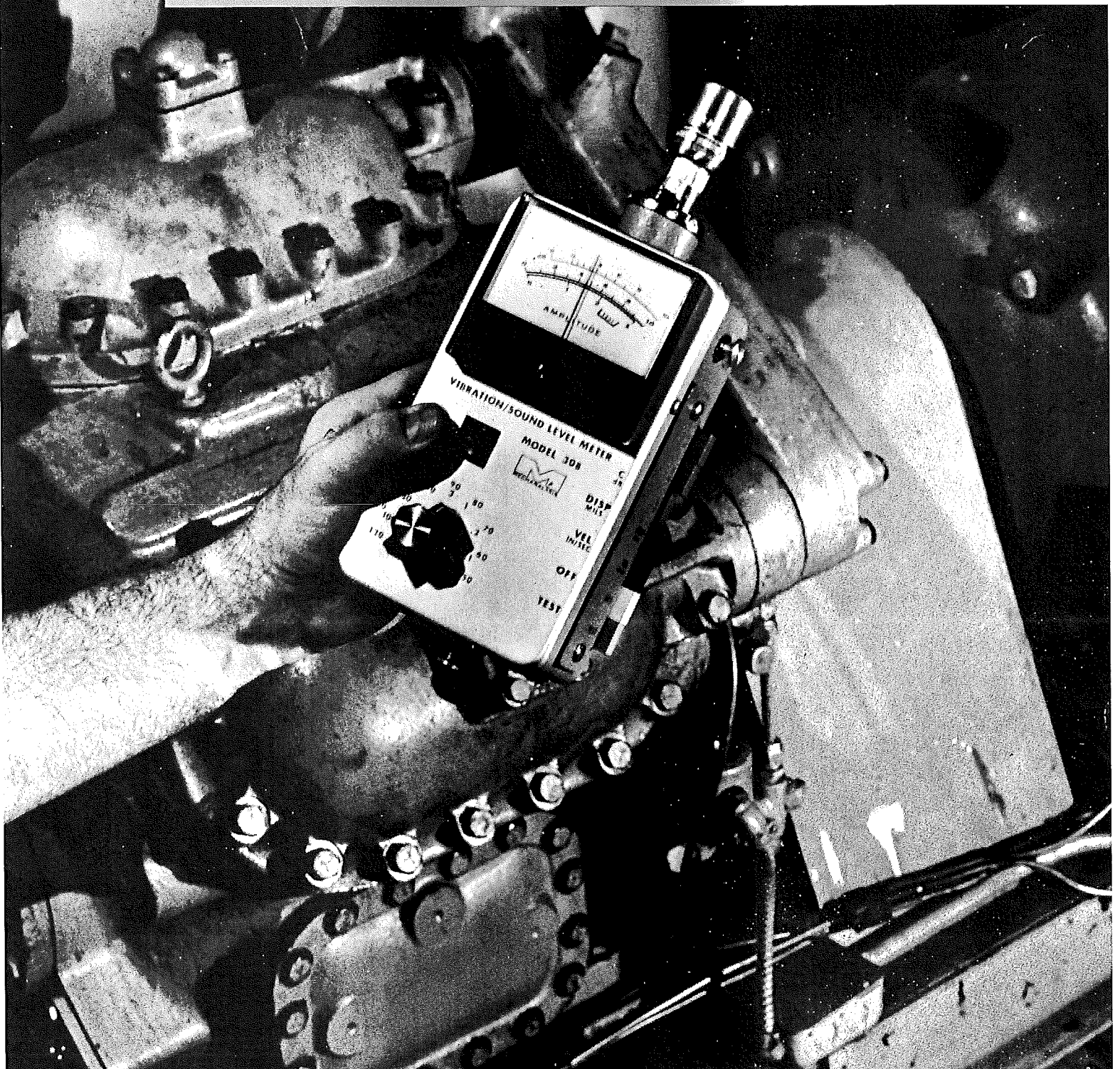


IRD Mechanalysis

MODEL 308

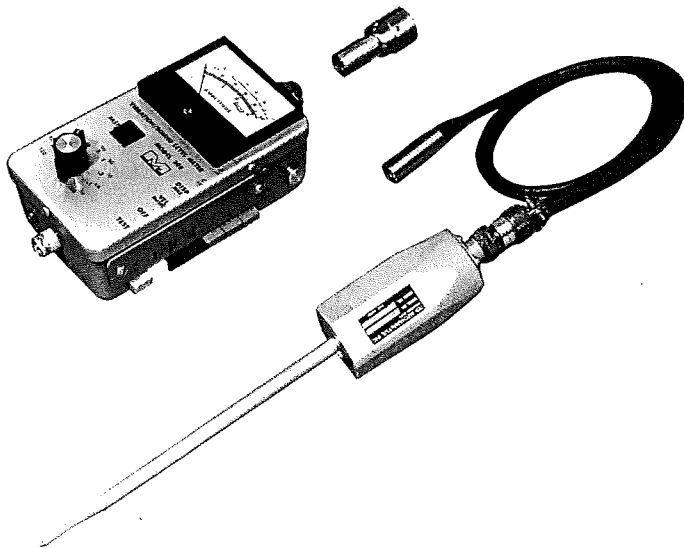
Vibration/Sound Level Meter



VIBRATION AND NOISE GO HAND-IN-HAND IN THE CONTROL OF MACHINERY

Today, most Preventive Maintenance Programs throughout industry depend on periodic vibration and noise measurements as the basis for determining machinery condition. Carried out together, they provide positive documentation—for controlling worker environment, product quality and production downtime.

The portable, self-powered Model 308 Vibration/Sound Level Meter combines the measurement of vibration and sound into one compact unit. Ruggedly constructed, the Model 308 meets the U.S. Department of Labor, Mine Safety and Health Administration requirements Schedule 2G, Approval No. 2G-2556, conforms to British Standard 3489:1962 and Canadian Standard Z107-1973 Specifications for Sound Level Meters (Industrial Grade).



MECHANALYSIS IN ACTION

— PREDICTING MAINTENANCE

Mechanalysis Portable Vibration Meters have been accepted as a standard for measuring machinery condition in all types of industry — worldwide.

Now, the 308 offers an effective, natural way to include noise control as an integral part of your basic Mechanalysis Program. Here's how the Program works:

The typical complement of Mechanalysis equipment would include the Model 308 and a portable Analyzer. Your initial survey will find those areas in your facility where vibration and/or sound levels are above established limits.

APPLICATIONS

The Mechanalysis Model 308 offers a universal way to measure both machinery vibration and noise in all phases of your operation. Typical applications include:

ENGINEERING/RESEARCH — a quick, positive means to accurately measure machinery vibration and noise in the laboratory, in your plant or in the field.

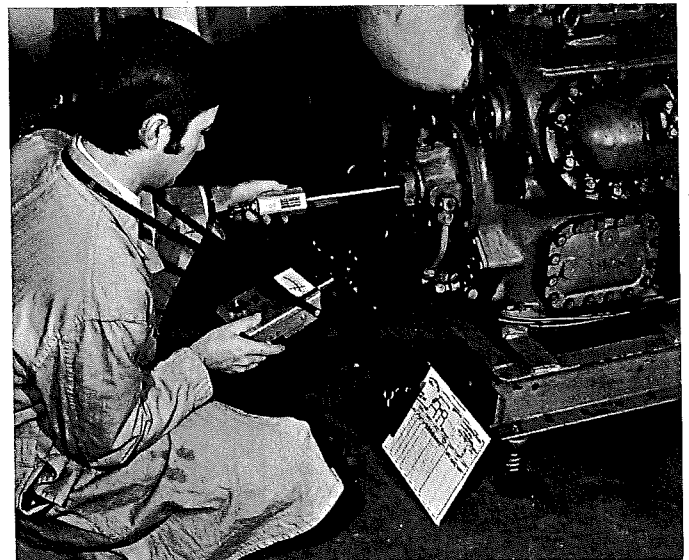
NOISE CONTROL — in compliance with latest Government Regulations — to establish a documented noise control program.

MACHINERY ACCEPTANCE — to assure smoother, longer life performance of mechanical equipment.

QUALITY CONTROL — for inspecting final products to reduce field problems and create greater customer acceptance.

PREVENTIVE MAINTENANCE — for locating machinery troubles early — to schedule maintenance and reduce downtime.

PRODUCTION INSURABILITY — to “periodically monitor the operation of equipment by the use of vibration measurement devices” — an established procedure by many insurance companies.



Then, through noise and vibration analysis you can **locate** the machinery source, **pinpoint** the cause and **correct** the specific problem, using the most effective, economical means.

A continuing program of periodic measurements, based on acceptable noise and vibration levels, will prevent unscheduled downtime, lower maintenance costs and increase production with the added benefit of a quieter plant.

The 308 can play an important role in expanding your Mechanalysis Program.

USING YOUR MODEL 308 FOR....

... VIBRATION MEASUREMENTS

The Model 308 includes a rugged, self-generating, velocity type vibration pickup recognized worldwide. The pickup is hand-held, with or without probe, for periodic measurements; shoulder strap supports the 308 to provide freedom for holding the vibration pickup and for recording the readings.

Vibration amplitude readings may be taken in Displacement or Velocity. Displacement is used primarily for measuring the condition of slower speed machinery, particularly where standards have been established. Velocity measurements, reflecting the amount of vibration displacement as well as the frequency, can be universally applied regardless of machine speed or type of trouble.

The 308 micro-power, solid-state circuitry, provides wide dynamic range and long battery life. From precision bearing inspection to shipboard maintenance, the 308 has the sensitivity for measuring a few microinches to 100 mils.

... SOUND MEASUREMENTS

It takes only a few seconds to replace the pickup cable with the microphone to have an extremely versatile, accurate, rugged Sound Level Meter.

With calibration traceable to N.B.S., the 308 is manufactured in accordance with the U.S. Government Quality Control Procedures, MIL-Q-9858, and meets the latest standards for a Type 2 Sound Level Meter, ANSI S1.4 1971 and I.E.C. 123:

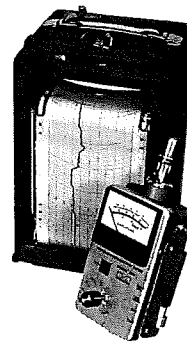
- Selectable A, B or C weighting to meet established codes and regulations — simulates human ear for various loudness levels.
- Selectable FAST response to measure impact and rapidly changing noise conditions.

The 308 is simple to use — requires no special training. Precise sound level readings can be obtained by anyone.

Detailed instructions and application information are included in the comprehensive Operation Manual. You'll be able to use your Model 308 immediately.

... TEMPORARY "TIME-HISTORY" RECORDING — in critical areas

Many machinery operating characteristics are relatively constant and can be evaluated in a short period of time. Others change with time, slowly or very abruptly. A permanent "time-history" recording of these changes can be made in either vibration or sound.



A recorder may be connected directly to the Model 308 DC output jack using the sub-miniature plug included. The 308 and Recorder can be moved to any location in your facility to obtain a "time-history" record of noise or vibration without an operator/observer. This permanent record can be an important document to show positive proof of compliance with the latest Noise Regulations involving employee "noise/time exposure".

... SOUND ANALYSIS



The primary function of the Model 308 is for periodic checks — as a part of a total Mechanalysis Program. When noise readings go up, a detailed analysis is performed to pinpoint the source. A Mechanalysis portable Analyzer (such as the Model 330, 340 or 350) can be used with the Model 308 to perform this noise analysis using the same basic, proven techniques as for machinery vibration analysis.

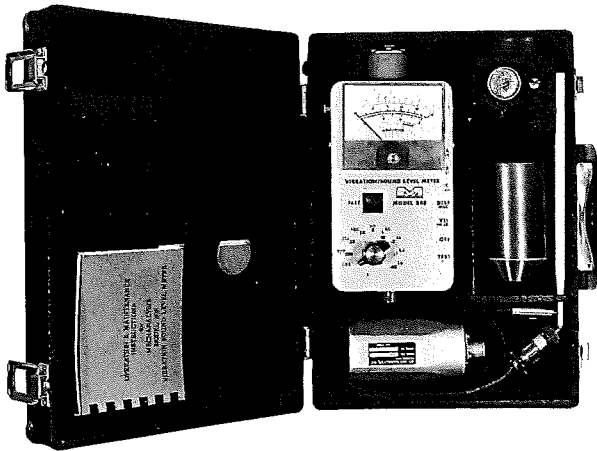
CUSTOMER TRAINING/RECOMMENDATIONS

Two-day Audio-Visual Basic Training Schools, covering machinery analysis and balancing, are held locally and periodically at no charge for all customers who have vibration analysis equipment — the minimum for a total Mechanalysis Program.

Mechanalysis Engineers will evaluate your needs and recommend a Program, without cost or obligation — including your minimum equipment requirements. To initiate this Recommendation use Form #537D.

GENERAL FEATURES

1982



- Common Input** - for microphone or vibration pickup cable
- Omnidirectional Microphone** - industrial type, humidity-proof
- Rugged Vibration Pickup** - Waterproof, velocity type
- Pushbuttons** - for simplicity, ease of operation
- A, B, or C weighting** - for comparing sound levels to establish standard
- Mercury batteries included** - for longer life — readily available and interchangeable with Alkaline or Zinc Carbon type
- A C output** - for using with portable Mechanalysis Vibration Analyzer — to determine noise frequencies and pinpoint source
- D C output** - for "time history", chart recording — for positive documentation
- FAST Response Pushbutton** - to measure impact and rapid changes
- Battery "lifesaver"** - carrying case cannot be closed with unit on
- Separate scales** - one for vibration and one for sound
- Sound Level Calibrator** (optional) - case storage built-in

SPECIFICATIONS

When ordering specify Model 308 for English Units of Measure or Model 308M for Metric Units of Measure

Vibration Measurements		Dimensions	Meter—9" x 4 1/2" x 3 1/4" (22.9 cm x 11.8 cm x 8.3 cm) Carrying Case—13 1/4" x 10 1/4" x 4 1/2" (33.7 cm x 26.1 cm x 11.5 cm)
Amplitude Ranges	In eight overlapping ranges—		
Displacement	English: 0-100 Mills Pk-Pk Metric: 0-3000 Microns Pk-Pk		
Velocity	English: 0-100 in/sec pk+ Metric: 0-3000 MM/sec pk+ + may be field calibrated for RMS	Weight	Meter—2 lbs. (0.9 Kg) Carrying Case with meter and standard accessories—8 lbs. (3.6 Kg) Shipping Weight 10 lbs. (4.5 Kg)
Sound Measurements		Standard Accessories	Microphone, Part No. 5294 Vibration Pickup, Model 544, Part No. 4526 Straight Probe, Part No. 1103 Pickup Cable, Part No. 12433 Leather Shoulder Strap, Part No. 3829 D. C. Recorder Plug, Part No. 9361 Carrying Case, Part No. 9375
Amplitude Ranges	In nine overlapping ranges— 45-140 dB (re .0002 Microbar or 20 Micronewtons/meter ²)		
Weighting Networks	A, B and C		
Analyzer Output	764 mV RMS Full Scale output into load of 100K ohms—for direct reading with portable Analyzer (Model 330, 340 or 350). (301 mV for 308M).	Optional Accessories	Magnetic Pickup Holder, Part No. 4332 Vice Grip Pliers, Part No. 1821 D. C. Chart Recorder, Part No. 9405 Sound Level Calibrator, Model 490
Frequency Range	600 - 600,000 CPM (10 - 10,000 Hz)		
Recorder Output	Compatible with Part No. 9405, or any strip chart Recorder having 200 microamp DC sensitivity and 5K ohm resistance.		
Operating Temperature Range	0° to 150°F (-18° to +65°C)	Unit Complies with	ANSI S1.4 1971 I.E.C. 123 Mine Safety and Health Administration Schedule 2G, Approval No. 2G-2556 Canadian Standard Association Specification Z107-1973 British Standard 3489:1962
Power	Two 8.4 Volt Mercury Batteries, Part No. 9291, 500 Hours Average Life		

** Formerly 6' Kit with Cable, P/N 9288*

Corporate Headquarters:

IRD Mechanalysis, Inc.

Subsidiary of H.H. Robertson Company

6150 Huntley Road
Columbus, Ohio 43229
614/885-5376

IRD Mechanalysis, Limited

333 Barton Street
Stoney Creek Hamilton
Ontario Canada
416/662-7577

IRD Mechanalysis (U.K.) Limited

Sealand Industrial Estate
Chester, England
44/244/374-914

IRD Mechanalysis S.A.

Avenue Winston Churchill 98
Brussels, Belgium
32/2/344.70.58

IRD Mechanalysis (Australia) Pty. Ltd.

337 Pacific Highway
Crows Nest, Australia
(02) 929-8122

IRD Mechanalysis (India) Private Ltd.

47-48 Jolly Maker
Nariman Point
Bombay, India
23-04-14

**OPERATION & MAINTENANCE
INSTRUCTIONS
for
MECHANALYSIS
MODEL 308
VIBRATION SOUND LEVEL METER**

Change B (PCO 1609) S/N 300 & on

**Manual Part No. 9765
Printed, April 1976**

IRD Mechanalysis, Inc.

Subsidiary of H. H. Robertson Company
6150 Huntley Road
Columbus, Ohio 43229

Offices in USA, Canada, United Kingdom, Western Europe and Australia

Copyright 1973 IRD Mechanalysis, Inc. Columbus, Ohio No. 12848 Litho in USA 173

TABLE OF CONTENTS

INTRODUCTION.....	iv
DESCRIPTION.....	1
General.....	1
- Measurement Mode Pushbuttons.....	1
FAST (Response) Pushbutton.....	5
Amplitude Meter and Range Selector.....	5
MICROPHONE/PICKUP Receptacle.....	6
ANALYZER and RECORDER Output Connectors.....	6
Batteries and Compartment.....	7
Vibration Pickup, Probe and Cable.....	7
Microphone.....	8
Carrying Case.....	8
SPECIFICATIONS.....	9
General Instrument Specifications.....	9
Instrument as Vibration Meter.....	10
Instrument as Sound Level Meter.....	11
Model 544 Vibration Pickup Specifications.....	11
Microphone (Part No. 5294) Specifications.....	14
Standard Accessories.....	15
Optional Accessories.....	15
OPERATION.....	17
General.....	17
Vibration Measurement.....	18
Sound Level Measurement.....	19
Using FAST Response Pushbutton.....	21
Utilizing RECORDER Output.....	21
Utilizing ANALYZER Output.....	24

VIBRATION MEASUREMENT TECHNIQUES AND APPLICATIONS.....	27
Applying the Pickup.....	27
Measuring Displacement.....	30
Measuring Velocity.....	30
Vibration Tolerances.....	31
Determining Dominant Frequency.....	32
Significance of Dominant Frequency.....	36
Vibration Measurement Applications.....	40
Preventive Maintenance.....	40
Balancing.....	42
Incoming Inspection.....	45
Field Service.....	45
Final Assembly Testing; Installation Checkout.....	46
 SOUND LEVEL MEASUREMENT TECHNIQUES AND APPLICATIONS.....	 48
Some Fundamentals of Sound and Noise.....	48
Basic Characteristics of Sound.....	48
What is Noise?.....	50
How Sound (or Noise) is Generated.....	50
The Decibel.....	53
Common Noise Sources and Levels.....	54
Industrial Noise.....	55
Acceptable Noise Levels for Different Working Areas.....	55
How the Ear Hears.....	57
A, B and C Weighting Networks.....	58
Sound Level Measurements.....	59
Relative Positions of the Meter and Operator.....	59
Measuring Machinery Noise.....	60
Selecting A, B and C Networks.....	64
Measuring Background Noise.....	65
When the Noise Level Oscillates with Time.....	65
Measuring Impact Noise.....	66
Frequency Analysis of Noise.....	67

**OPERATION & MAINTENANCE
INSTRUCTIONS
for
MECHANALYSIS
MODEL 308
VIBRATION SOUND LEVEL METER**

Change B (PCO 1609) S/N 300 & on

**Manual Part No. 9765
Printed, April 1976**

IRD Mechanalysis, Inc.

Subsidiary of H. H. Robertson Company

6150 Huntley Road

Columbus, Ohio 43229

Offices in USA, Canada, United Kingdom, Western Europe and Australia

Copyright 1973 IRD Mechanalysis, Inc. Columbus, Ohio No. 12848 Litho in USA 173

TABLE OF CONTENTS

INTRODUCTION.....	iv
DESCRIPTION.....	1
General.....	1
- Measurement Mode Pushbuttons.....	1
FAST (Response) Pushbutton.....	5
Amplitude Meter and Range Selector.....	5
MICROPHONE/PICKUP Receptacle.....	6
ANALYZER and RECORDER Output Connectors.....	6
Batteries and Compartment.....	7
Vibration Pickup, Probe and Cable.....	7
Microphone.....	8
Carrying Case.....	8
SPECIFICATIONS.....	9
General Instrument Specifications.....	9
Instrument as Vibration Meter.....	10
Instrument as Sound Level Meter.....	11
Model 544 Vibration Pickup Specifications.....	11
Microphone (Part No. 5294) Specifications.....	14
Standard Accessories.....	15
Optional Accessories.....	15
OPERATION.....	17
General.....	17
Vibration Measurement.....	18
Sound Level Measurement.....	19
Using FAST Response Pushbutton.....	21
Utilizing RECORDER Output.....	21
Utilizing ANALYZER Output.....	24

VIBRATION MEASUREMENT TECHNIQUES	
AND APPLICATIONS.....	27
Applying the Pickup.....	27
Measuring Displacement.....	30
Measuring Velocity.....	30
Vibration Tolerances.....	31
Determining Dominant Frequency.....	32
Significance of Dominant Frequency.....	36
Vibration Measurement Applications.....	40
Preventive Maintenance.....	40
Balancing.....	42
Incoming Inspection.....	45
Field Service.....	45
Final Assembly Testing;	
Installation Checkout.....	46
SOUND LEVEL MEASUREMENT TECHNIQUES	
AND APPLICATIONS.....	48
Some Fundamentals of Sound and Noise.....	48
Basic Characteristics of Sound.....	48
What is Noise?.....	50
How Sound (or Noise) is Generated.....	50
The Decibel.....	53
Common Noise Sources and Levels.....	54
Industrial Noise.....	55
Acceptable Noise Levels for	
Different Working Areas.....	55
How the Ear Hears.....	57
A, B and C Weighting Networks.....	58
Sound Level Measurements.....	59
Relative Positions of the Meter	
and Operator.....	59
Measuring Machinery Noise.....	60
Selecting A, B and C Networks.....	64
Measuring Background Noise.....	65
When the Noise Level Oscillates	
with Time.....	65
Measuring Impact Noise.....	66
Frequency Analysis of Noise.....	67

Noise Measurement Applications.....	71
Preventive Maintenance.....	71
Quality Control.....	72
Field Service.....	72
Personnel and Community Problems.....	72
Personnel Efficiency.....	73
Safety.....	74
Community Noise Pollution.....	74
Hearing Damage.....	75
Documentation.....	79
MAINTENANCE.....	80
Battery Replacement.....	80
Troubleshooting.....	80
Accuracy Test - Sound.....	80
Calibration.....	82
Calibration Period.....	82
Test Equipment Required.....	82
Calibration Procedure.....	83
Circuit Description.....	85
PARTS LIST.....	87
Major Components and Accessories.....	87
Circuit Components.....	87

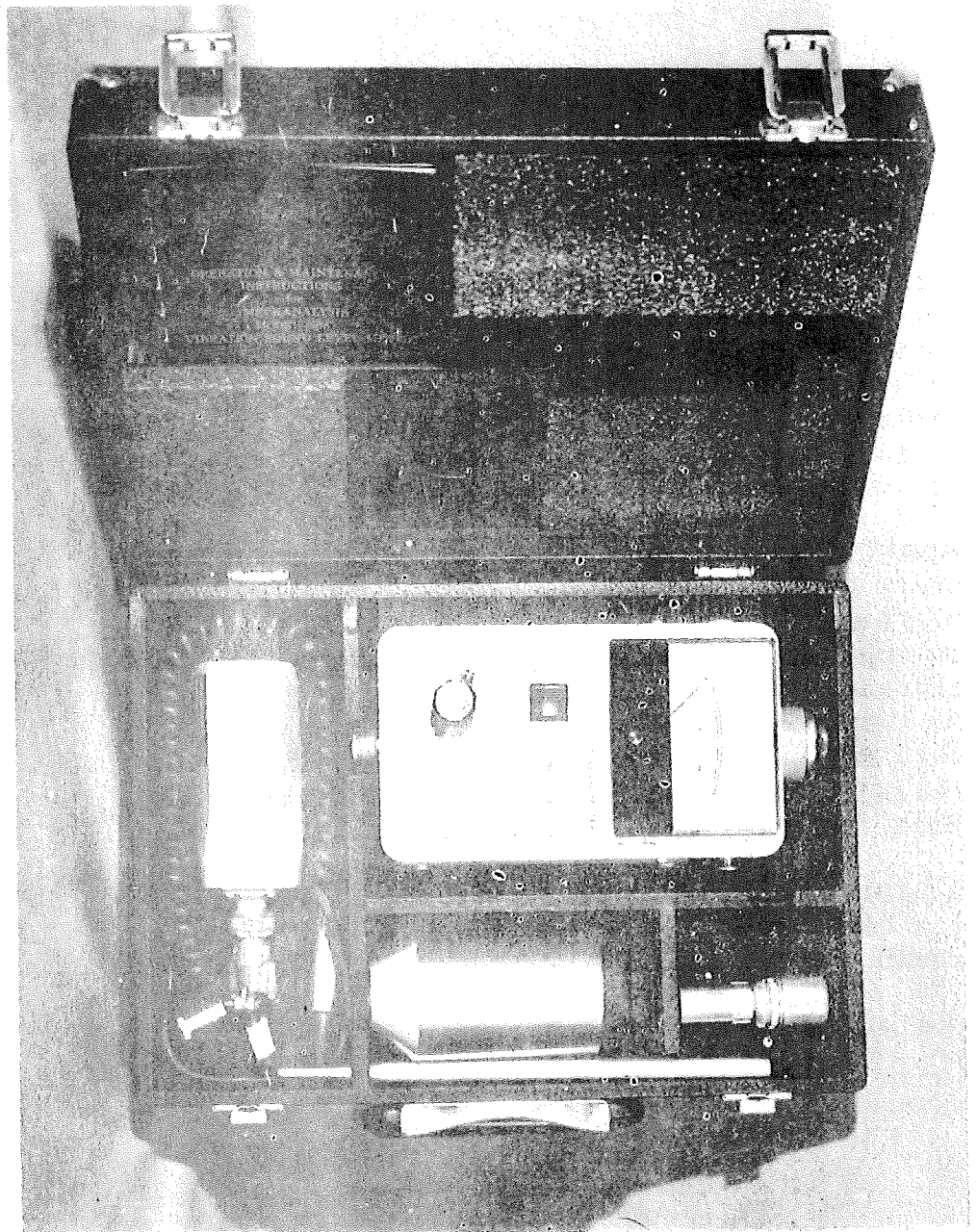


Figure 1. Model 308 Vibration/Sound Level Meter

INTRODUCTION

The Model 308 Vibration/Sound Level Meter, by combining in a single instrument the capability of measuring either vibration or sound, provides a unique three-fold approach to the control of machinery problems and noise pollution.

1. Conditions in a machine that can eventually result in breakdown can be detected by periodic vibration readings of the machine, using the Model 308. As periodic readings increase trouble is indicated. The cause of the trouble can then be analyzed and corrected, preferably with the use of a Vibration Analyzer/Dynamic Balancer instrument.

2. As a general rule, an increase in the vibration of a machine will also result in increased noise levels near the machine. Using the Model 308 for periodic noise measurements in the immediate area of specific machines can indicate developing trouble in the same manner as vibration readings. In many cases one type of measurement will confirm the trouble indicated by the other. Additionally, it is important to note that periodic noise measurements can uncover some types of machinery problems which might not be detected by vibration measurements.

3. The Model 308 provides the means for carrying out an effective program of noise pollution measurement and control. Such programs, whether elective or to achieve compliance with Local, State or Federal "Standards," imply the use of a sound level meter which will provide consistent accuracy as related to accepted measurement standards. To provide this accuracy, the Model 308 is designed

to meet or exceed the specifications of American National Standards Institute (ANSI) S1.4-1971 for Type 2 Sound Level Meters, and International Electrotechnical Commission (IEC) Recommendation 123 (1961) and British Standard BS3489: 1962.

This manual fully describes the Model 308 Vibration/Sound Level Meter and provides details on its operation, application and maintenance. It is recommended that the manual be read throughout before the instrument is used.

Combined with the knowledge represented in this manual, the Model 308 is an effective and valuable tool for dealing with many types of routine vibration and noise problems. However, problems beyond the "routine" require more sophisticated equipment and more knowledge. IRD Mechanalysis offers both. An extensive line of analysis equipment (including Real Time) is available, and is backed by complete and complimentary training courses in both vibration and sound, at basic and advanced levels. Basic courses are available in all Mechanalysis Districts, worldwide.

DESCRIPTION

GENERAL

The Model 308 Vibration/Sound Level Meter, figure 1, provides the capability of measuring either vibration or sound in one compact, easy to use instrument. The Model 308M Vibration/Sound Level Meter (not illustrated) is identical to Model 308 except that vibration amplitude is read in Metric units instead of English units. All information relative to Model 308 applies equally to Model 308M except where specifically stated otherwise. The portable, battery-powered meter is supplied with a rugged carrying case which also holds the instrument manual, microphone, vibration pickup, and pickup accessories provided. A carrying strap for the meter simplifies measurements and data recording. Figures 2 and 3 illustrate the Model 308 being used as a vibration meter and as a sound level meter.

The Model 308 is designed to meet the specifications of ANSI Standard S1.4-1971 and IEC Recommendation 123 (1961). Micro-power integrated circuitry in the meter ensures reliability, extended battery life, and linear accuracy over a wide frequency range.

Specific details of controls and components are given in the remaining paragraphs of this section. Meter features are illustrated in figure 4.

MEASUREMENT MODE PUSHBUTTONS

Two vibration measurement modes (black DISP and VEL pushbuttons) and three sound level measurement



Figure 2. Model 308 Used as Vibration Meter

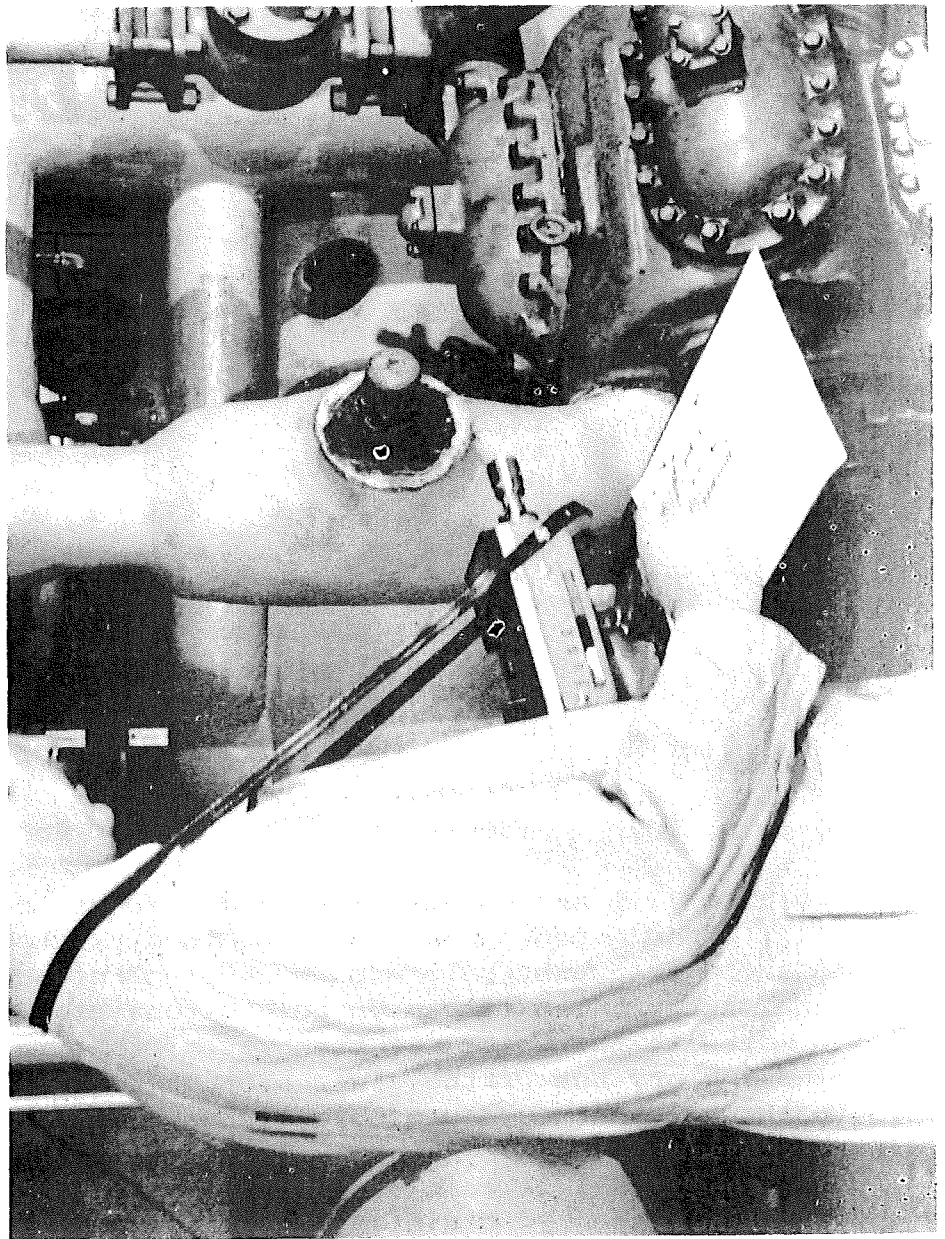


Figure 3. Model 308 Used as Sound Level Meter

given in the Operation section.

MICROPHONE/PICKUP RECEPTACLE

The MICROPHONE/PICKUP receptacle accepts either the microphone or the vibration pickup cable connector. The receptacle is designed to positively lock the mating connector when fully seated; the release button on the receptacle must be depressed to remove the microphone or pickup cable connector.

ANALYZER AND RECORDER OUTPUT CONNECTORS

The ANALYZER and RECORDER output connectors are shown in figure 4. The ANALYZER output provides a means of frequency analysis of sound level measurements. The output is interconnected with the pickup input of a Mechanalysis Vibration Analyzer/Dynamic Balancer (Model 330, 340 or 350). The analyzer filter is then tuned to locate the specific frequencies contributing to the overall amplitude indicated on the Model 308. The amplitude of each frequency located can also be determined.

The RECORDER output provides a means of obtaining Amplitude vs Time recordings of vibration or sound levels monitored with the Model 308. The output is a d-c voltage which is proportional to the amplitude of the vibration or sound level being monitored, and is compatible with a variety of d-c recorders. A jack which mates with the RECORDER connector is provided as standard equipment with the meter. Recordings of vibration levels can be very useful for purposes such as studying the effects of various changes (load, temperature, etc.) or for more continuous monitor-

ing of a machine when the measurements are approaching critical levels. Sound-level recordings are similarly useful for machinery problems, and for purposes such as determining maximum area noise levels to which personnel are or may be exposed, and duration of exposure.

Additional details regarding the ANALYZER and RECORDER outputs are given in the Operation and Specifications sections.

BATTERIES AND COMPARTMENT

The battery compartment is located behind the access cover plate above the mode selector push-buttons. Two 8.4-volt mercury batteries are supplied; polarized snap-on connectors permit foolproof battery installation. The access cover is secured with two captive screws.

VIBRATION PICKUP, PROBE AND CABLE

The Model 544 Vibration Pickup may be used with or without the 9-inch accessory probe provided. The pickup is interconnected with the meter MICROPHONE/PICKUP receptacle using the 6-foot retractile cable. The pickup produces an electrical output voltage proportional to the vibration velocity of the machine part to which it is applied. (Circuitry in the meter converts the velocity-related signal to a displacement-related signal, when the DISP mode is selected.) Complete characteristics are given in the Specifications section.

The pickup may be mounted using a 1/4-28 stud (welded or threaded to the machine part) to mate

with the hole in the pickup end cap. It may also be hand-held. Mounting position does not affect sensitivity or accuracy. For hand-held measurements, the end of the pickup may be applied directly to the point of interest, or the 9-inch probe may be installed; the probe permits better access to hard-to-reach points. Optional Vise Grip or Magnetic Holders permit quick, "hands-free" application of the pickup.

MICROPHONE

The microphone is omnidirectional (equally sensitive to sound arriving from all directions) and utilizes a ceramic sensing element. The microphone features a wide frequency response and is designed strictly for sound level measurements. (See Specifications section for additional details.) The microphone installs directly in the MICROPHONE/PICKUP receptacle, thus eliminating cable noise or cable impedance matching problems. (Use of an extender cable for connecting the microphone to the Model 308 is not recommended.)

CARRYING CASE

The carrying case is divided into compartments for the instrument, operation manual, and various accessories. Foam padding in the compartments provide additional protection for the meter and accessories. A projection in the meter compartment depresses the OFF pushbutton when the meter is placed in the compartment. Space is provided in the carrying case for two spare meter batteries, and for the optional Sound Level Calibrator (see "Optional Accessories").

SPECIFICATIONS

GENERAL INSTRUMENT SPECIFICATIONS

RECORDER Output:	D-C output proportional to amplitude meter reading. Compatible with strip chart recorders having 200 microampere d-c sensitivity, 5000 ohms resistance.
ANALYZER Output:	A-C output proportional to meter reading. Full-scale a-c output is 764 millivolts (301 millivolts, Model 308M) rms into an impedance of 100,000 ohms. (Compatible with Mechanalysis Model 330, 340 or 350 Vibration Analyzer/Dynamic Balancer instruments or conventional oscilloscopes.)
Battery requirements:	Two NEDA Type 1604 8.4-volt or 9-volt batteries. (Two 8.4-volt mercury batteries supplied.)
Suitable Battery Types and Average Life:	1. Mercury; approximately 500 hours. (Mallory Duracell TR 146X; Eveready E146X; Burgess 146X.) 2. Alkaline; approximately 300 hours. (Mallory MN1604; RCA 1323.) 3. Zinc-Carbon; approximately 150 hours. (Eveready 216; Burgess 2U6; RCA VS323; Mallory M1604.)
Battery Condition:	TEST pushbutton provides meter indication of battery condition.

Temperature Range:	0°F to 150°F. (-18°C to 65°C)
Overall Dimensions:	Instrument 9 x 4-5/8 x 3-1/4 inches (22.9 x 11.8 x 8.3 cm) Carrying Case 13-1/4 x 10-1/4 x 4-1/2 inches. (33.7 x 26.1 x 11.5cm)
Weight:	Instrument with batteries: 2 pounds (0.9 Kg) Instrument with carrying case and accessories: 8 pounds (3.6Kg) Shipping weight: 10 pounds (4.5Kg)

INSTRUMENT AS VIBRATION METER

Frequency Range:	720 to 60,000 CPM (12 to 1000 Hz) , with Model 544 Vibration Pickup used as sensing transducer. (Instrument range is 300 to 600,000 CPM, or 5 to 10,000 Hz.)
Maximum Sensitivity:	Peak-to-Peak Displacement: 0.001 mils (0.03 microns, Model 308M). Peak Velocity: 0.001 inch per second (0.03 millimeter per second, Model 308M).
Amplitude Ranges:	Peak-to-Peak Displacement: 0 to 100 mils (0 to 3000 microns, Model 308M), in eight overlapping ranges. Peak Velocity: 0 to 100 inches per

second (0 to 3000 millimeters per second, Model 308M), in eight overlapping ranges.

INSTRUMENT AS SOUND LEVEL METER

Design Standards:	Meets or exceeds ANSI S1.4-1971 (Type 2) and IEC Recommendation 123 (1961) and British Standard BS3489: 1962
Frequency Response Weighting Networks:	A, B and C, per ANSI S1.4-1971.
Frequency Range:	20 to 10,000 Hz (1200 to 600,000 CPM), with Microphone Part No. 5294 used as sensing transducer. (Instrument range is 5 to 10,000 Hz, or 300 to 600,000 CPM.)
Amplitude Range:	45 to 140 dB (re 0.0002 microbar) in nine overlapping ranges, for A, B or C weighting networks.
Meter Response Rates:	"Slow" and "Fast" per ANSI S1.4-1971. Slow response except when FAST pushbutton is depressed.

MODEL 544 VIBRATION PICKUP SPECIFICATIONS

Type:	Seismic velocity; self-generating. The sensitive axis is the longitudinal axis, and is perpendicular to the mounting surface.
-------	---

Output Sensitivity:	240 (± 24) millivolts ac (rms) output for a peak-to-peak displacement of 0.001 inch (1 mil) at 100 Hz (6000 CPM). This corresponds to a Velocity Constant of 1.08 volts ac (peak) output per inch per second of peak vibration velocity. Sensitivity is unaffected by orientation.
Orientation:	May be used in any mounting position without adjustment or correction.
Frequency Response:	Room ambient ($\pm 77^{\circ}\text{F}$): $\pm 8\%$ over the frequency range 12-1000 Hz; down $8\% \pm 13\%$ @ 10 Hz; pickup frequency response drops exponentially at lower frequencies. Elevated ambient ($+ 250^{\circ}\text{F}$): $\pm 13\%$ over the frequency range 12-1000 Hz. The above limits are total variations for any mounting position of the pickup.
Transverse Response:	Average transverse response less than 5% of the longitudinal response, over the frequency range 10-1000 Hz.
Natural Resonant Frequency:	16 Hz critically damped at $+ 77^{\circ}\text{F}$.
Amplitude Range:	Minimum: limited only by amplifier gain and noise level. Maximum: 0.125 inch peak-to-peak displacement up to 70 Hz; 30 g's

	peak acceleration above 70 Hz.
Amplitude	$\pm 5\%$ from 0.0001 to 0.1 inch peak-
Linearity:	to-peak displacement.
Recommended	2.5 g's at 20 Hz to 30 g's above
Maximum	70 Hz, continuous.
Acceleration:	
Damping Characteristic:	The pickup has a damping factor of approximately 0.7 which results in essentially flat operation over the frequency range. This provides improved accuracy and improved transient response for low frequency operation.
Magnetic Field Sensitivity:	Without shielding: 0.15 in/sec/gauss. With 10:1 Shield (Part No. 1157): 0.015 in/sec/gauss. With 100:1 Shield (Part No. 3563): 0.0015 in/sec/gauss.
Electrical Impedance:	2,000 (± 200) ohms DC resistance.
Temperature Range:	-40°F to 500°F.
Humidity:	Pickup case and connector are watertight. Pickup performance is unaffected by humidity, condensation, and immersion in water for short periods.

Construction: High-temperature solder connections.
Machined aluminum case.

Mounting: One 1/4-28 x 1/4" tapped hole for
mounting to 1/4-28 stud in machine
or in suitable bracket.

Weight & Dimensions: 21 ounces. 4-7/8" long x 2-3/16"
diameter.

Output Connector: ITT Cannon GS02-10SL-4P-111 High-
Temperature, Hermetically Sealed
(or equivalent).

MICROPHONE (PART NO. 5294) SPECIFICATIONS

Type: Piezoelectric - ceramic; omni-
directional.

Electrical Impedance: 460 pf capacitive (at 77°F).

Frequency Response: 20 to 10,000 Hz.

Sensitivity: -60 ($\pm$ 2) dB re 1 volt per microbar.

Distortion: 1% or less total harmonic distortion
at 150 dB sound pressure level.

Temperature Range: -50°F to +150°F.

Sound Pressure Extremes: Cartridge will withstand momentary
sound pressures in excess of 160 dB
sound pressure level and 150 dB

Extremes: sound pressure level for at least 100 hours with no measurable change in characteristics.

Humidity: Cartridge will withstand 95 to 100% humidity for at least 1000 hours without deterioration.

STANDARD ACCESSORIES

- 1 - Model 544 Vibration Pickup, Part No. 4526
- 1 - Straight Probe, Part No. 1103
- 1 - 4 foot Pickup Cable, Part No. 12433
- 1 - 6 foot Retractable Pickup Cable, Part No. 9288
- 1 - Microphone, Part No. 5294
- 1 - Carrying Strap, Part No. 3829
- 1 - Operation Manual, Part No. 9765
- 1 - Plug, RECORDER Output, Part No. 9361
- 1 - Carrying Case, Part No. 9375

OPTIONAL ACCESSORIES

Spare Battery, 8.4-volt Mercury, Part No. 9291.
(2 Required.)*

Sound Level Calibrator, Model 490. (Secondary standard introduces known sound pressure level directly to microphone; use ensures consistent accuracy of sound level measurements.)

D-C Recorder, Strip Chart, Part No. 9405. For Vibration or Sound Level recordings, utilizing Model 308 RECORDER output. 117-volt, 60-Hz operation (234-volt, 50-Hz operation available.

* See "General Instrument Specifications" for suitable battery types available locally.

on request). Ten selectable chart-drive speeds: 3/4, 1-1/2, 3, 6 and 12 inches per hour, and 3/4, 1-1/2, 3, 6 and 12 inches per minute.

(Maximum of 68 days continuous recording at 3/4 inch per hour.) Visual readout scales of 0 to 1 (linear) and -5 to +10 (dB, logarithmic) on recorder. Includes Accessory Kit (ink, pen filler, pen cleaner); one 103-foot roll of linear chart paper (0 to 1 scale); one 103-foot roll of logarithmic chart paper (-5 to +10 dB scale); one Recorder-to-Model 308 Interconnecting Cable, Part No. 9494; and one instruction manual. Additional details and specifications available on request.

Recorder Chart Paper, 103-foot roll, 0 to 1 linear scaling, Part No. 9406. (For 9405 Recorder.)

Recorder Chart Paper, 103-foot roll, -5 to +10 dB logarithmic scaling, Part No. 9469. (For 9405 Recorder.)

Magnetic Pickup Holder, Part No. 4332. (For use with Model 544 Vibration Pickup.)

Vise Grip Pickup Holder, Part No. 1821. (For use with Model 544 Vibration Pickup.)

Amplitude Meter Scale Overlay. (Provides dB scale on analyzer amplitude meter for performing sound analyses.)

Model 330 - Overlay Part No. 5337

Model 340 - Overlay Part No. 5868

Model 350 - Overlay Part No. 9558

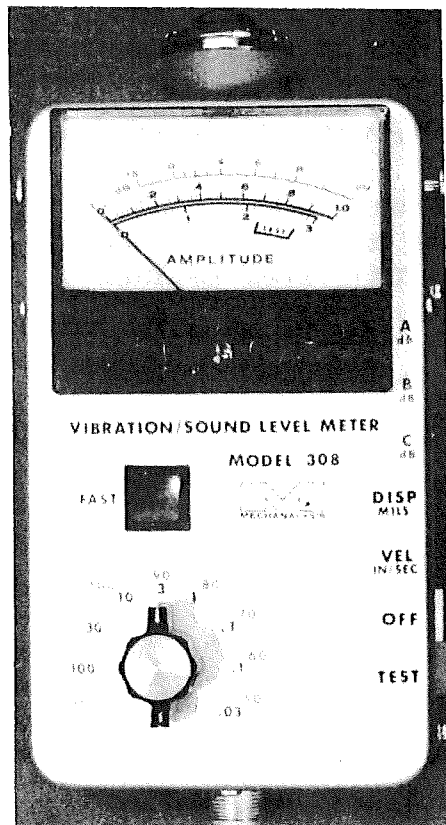
Model 600 - Overlay Part No. 9688

OPERATION

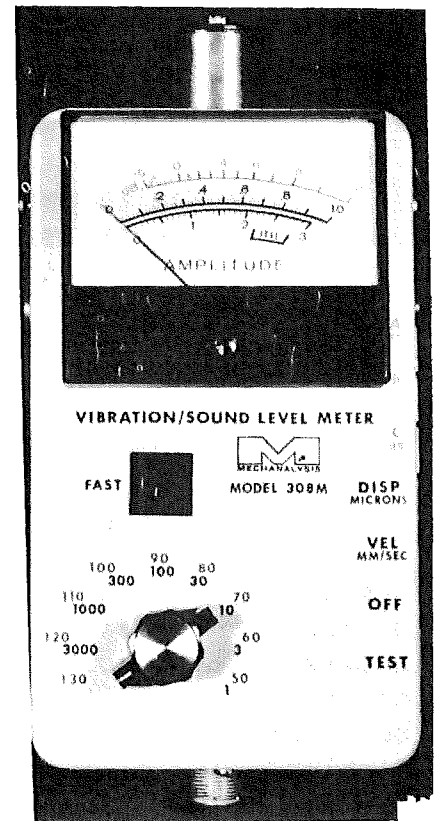
GENERAL

The scope of this section is limited to basic operating details. Actual instrument usage is described in practical terms in the following two sections, Vibration Measurement Techniques and Applications, and Sound Level Measurement Techniques and Applications.

Figure 5 illustrates controls and other meter details which will be discussed in this section.



English Unit



Metric Unit

Figure 5. Model 308 Panel Details

VIBRATION MEASUREMENT

The following steps are the basic requirements for preparing and using the meter for vibration measurements:

1. Confirm that the OFF pushbutton is depressed. Attach the carrying strap to the studs on the sides of the meter.
2. Connect the vibration pickup to the meter with the pickup cable. Press cable connector firmly into PICKUP receptacle to ensure that lock engages.
3. Select desired DISP or VEL measurement mode.
4. Depress the TEST pushbutton and confirm readout within the TEST area on the amplitude meter. If readout is below TEST area replace batteries as described in Maintenance section.
5. Apply the pickup to the point to be measured. (If pickup is to be threaded onto a mounting stud, disconnect cable at meter end.)
6. For each point to be measured set the range selector to successively lower (or higher) ranges until a meter reading within the upper two-thirds of the black scales is obtained. (This provides better meter accuracy than readings in the lower third of the scales.) The amplitude reading will be in mils (microns, Model 308M) of peak-to-peak displacement, or in inches per second (millimeters per second, Model 308M) of peak velocity, depending on whether the DISP or VEL mode is selected.

The black 0 to 1 scale is read if the range selected is ".1", "1", "10" or "100" ("1", "10", "100" or "1000", Model 308M), and the black 0 to 3 scale is read if the range selected is ".03", ".3", "3" or "30" ("3", "30", "300" or "3000", Model 308M). The meter full-scale value is equal to the range selected. For example, a reading of 2 on the 0 to 3 scale represents a value of 2 if the "3" range is selected, or a value of 20 if the "30" range is selected. Similarly, a reading of 0.6 on the 0 to 1 scale represents a value of 60 if the "100" range is selected.

7. Record the value of each measurement on a suitable data form, such as the one shown in figure 13 of the next section. (This form provides space for entering all pertinent information required, including sound level measurements.)

8. If the meter is to be used for an extended period of time, recheck the batteries once each hour and at the end of the use period. This practice will help to ensure consistently accurate readings.

SOUND LEVEL MEASUREMENT

The following steps are the basic requirements for preparing and using the meter for sound level measurements:

1. Confirm that OFF pushbutton is depressed. Attach the carrying strap to the studs on the sides of the meter.

2. Install the microphone in the MICROPHONE receptacle; press in firmly to ensure that lock

engages.

3. Select desired A, B or C weighting network.

4. Depress the TEST pushbutton and confirm readout within the TEST area on the amplitude meter. If readout is below TEST area replace batteries as described in Maintenance section.

NOTE

It may be desirable to check the meter for proper sound level calibration prior to each day's usage (with Sound Level Calibrator, Part No. 9404). If this is the case, refer to "Accuracy Test - Sound" in the Maintenance section.

5. Place the meter in position for the measurement, with microphone properly oriented.

6. For each measurement position, set the range selector to successively lower (or higher) ranges until a meter reading within 0 to +10 on the red dB scale is obtained. (This provides better meter accuracy than when readings are between -5 to 0 on the scale.) The value of the dB scale reading is added to the value of the range selector red position number ("50", "60", "70", etc.), to obtain the sound level reading in dB. With a range setting of "70", a scale value of +5 would indicate a sound level of 75 dB, and a scale value of -2 would indicate a sound level of 68 dB. (In the last case, selecting the "60" range would result in a scale value of +8 dB, thus giving the same 68 dB result, but with better meter accuracy

and scale readability.)

7. Record each measurement on a suitable data form which has space to include all other information pertinent to the measurement. When recording measurements, the weighting network (A, B, C) used must be noted on the data sheet, or with the individual measurement values as indicated in the following examples: 79 dB(A); 85 dB(B), 92 dB(C), etc. If the measurements are being taken as part of a machinery preventive maintenance program, a dual-purpose form with space for both sound and vibration readings may be used (see figure 13 in the following section).

8. If the meter is to be used for an extended period of time recheck the batteries once each hour and at the end of the use period. This practice will help to ensure consistently accurate readings.

Using FAST Response Pushbutton

If the sound level being measured is not relatively constant, and has short-duration "peaks," a better approximation of the highest sound level will be obtained by depressing the FAST response pushbutton. This reduces the amount of electrical meter damping which is normally in the circuit to provide "slow" response. (Slow" and "Fast" response rates are as defined by ANSI.)

UTILIZING RECORDER OUTPUT

The RECORDER output is a d-c voltage which varies directly in proportion to the amplitude meter reading. The output may be used to obtain Ampli-

tude vs Time recordings of either vibration or sound levels. The Mechanalysis D-C Recorder (Part No. 9405) is ideally suited for this purpose. Other d-c recorders with a full-scale sensitivity of up to 200 microamperes with input resistance of 5000 ohms may also be used, with proper impedance matching. The RECORDER jack mating plug provided and a suitable two-conductor cable are used to interconnect the meter and recorder. The amplitude meter of the Model 308 is automatically switched out of the circuit when the mating plug is inserted in the RECORDER jack; positive d-c output voltage is applied to the tip (or center conductor) of the plug.

The full-scale d-c output (for any amplitude range) is one volt at 200 microamperes into a d-c impedance of 5000 ohms. D-C Recorder Part No. 9405 is furnished with Cable Part No. 9403. It requires no special matching and may be connected directly to the meter. Impedance matching requirements for other recorders should be such as to draw 200 microamperes into 5000 ohms at full-scale meter signal.

NOTE

Impedance matching errors will result in recorded amplitude errors.

If the recorder to be used has a variable sensitivity control, it may be calibrated by (1) applying a constant vibration to the pickup or a constant sound pressure level to the microphone, (2) observing the resulting meter reading, and (3) connecting the recorder and adjusting the amplitude for the previously observed meter value.

NOTE

- When making sound level recordings to determine maximum personnel exposure levels occurring over a given time period, use of 90 dB or higher ranges is recommended since recorded levels which exceed 90 dB(A) are of primary interest.
- For vibration recordings, use the amplitude range which will include the maximum vibration amplitude anticipated.

UTILIZING ANALYZER OUTPUT

The ANALYZER output is primarily intended to permit frequency analysis of sound level measurements, using a Mechanalysis Model 330, 340 or 350 Vibration Analyzer/Dynamic Balancer. The output may also be used for oscilloscope observation, when using either vibration or sound level measurement modes. (A suitable mating connector for scope interconnection is IRD Mechanalysis Part No. 4366 or ITT Cannon MS3106E-10SL-4S, or the equivalent.) The output signal is an a-c voltage proportional to the meter reading. The full-scale a-c output (for any amplitude range) is 764 millivolts (301 millivolts, Model 308M) rms into an impedance of 100K ohms.

Use of the ANALYZER output for frequency analysis of vibration measurements would be redundant; that is, if vibration frequency analysis (or balancing with phase readout) is desired, simply connect the vibration pickup directly to the Analyzer/Balancer instrument.

For frequency analysis of sound level measurements proceed as follows:

1. The C network on the Model 308 should be selected for all analysis work. (The purpose of analysis is to detect all frequencies contributing to the noise. This purpose will be defeated if the A or B network is selected, since lower frequencies may be attenuated to the point where they cannot be detected.)
2. Connect Analyzer pickup cable to Model 308 ANALYZER connector and to Analyzer PICKUP connector.

3. On the analyzer, set the DISP/VEL selector to "VEL" and the amplitude range selector to 1. (On metric units, set amplitude selector to 10.)

4. Adjust the Model 308 range selector for a meter reading on the dB scale.

5. Apply power to the analyzer and analyze the input signal in the same manner as for vibration frequency analysis. (Refer to analyzer operation manual for details.)

6. The amplitude of the frequency component that is "tuned in" is equal to the sum of the dB range switch setting on the Model 308 plus the dB meter reading on the analyzer.

If this amplitude is too small to read on the analyzer meter, the analyzer amplitude range switch should be switched to a lower scale. Each step is equivalent to subtracting 10 dB from the dB shown on the Model 308 range switch. (Do not reduce analyzer switch more than 2 steps, that is, 20 dB. Filter overloading may occur and erroneous reading obtained.) The dB sound pressure level of the "tuned in" frequency is equal to the sum of the Model 308 dB setting minus 10 dB for each analyzer step change plus dB reading on the analyzer meter.

For example, if the Model 308 is set to 60 dB, and the analyzer to .3 (for metric units, the analyzer range switch would be set at 3), and the analyzer meter reads +9 dB, the sound pressure level of the "tuned in" frequency is $60 \text{ dB} - 10 \text{ dB} + 9 \text{ dB}$ or 59 dB. See Figure 5A.

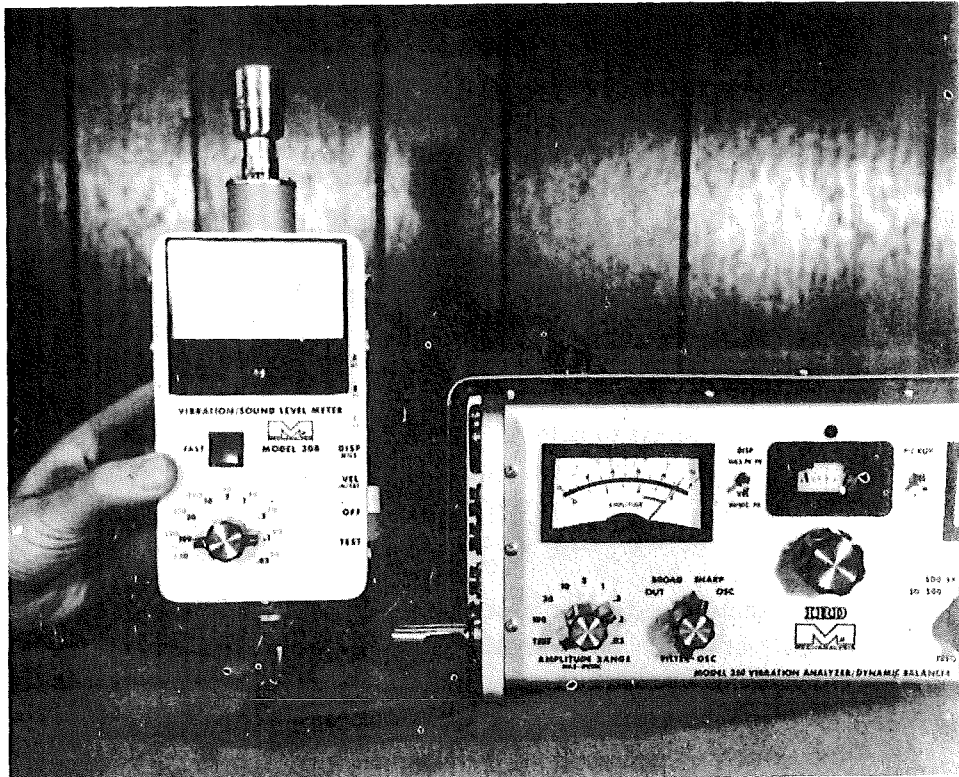


Figure 5A. The filtered sound pressure level component reading is +59 dB. It is the sum of the Model 308 and 350 amplitude range selector settings and the Model 350 amplitude meter readings +60 dB, -10 dB and +9 dB respectively.

VIBRATION MEASUREMENT TECHNIQUES AND APPLICATIONS

APPLYING THE PICKUP

Meaningful and accurate machinery vibration readings require reasonable care in selecting the points (on the machine) to be measured, and proper application of the pickup to those points.

The most significant measurement points will usually be at the bearings which support the major rotating component(s), or on solid machine structure as near the bearings as possible. These points are the best "transmitters" of the machine's vibration.

At a given measurement point (or bearing) on the machine, three "standard" measurement positions of the pickup may be used. These positions - "Axial," "Vertical" and "Horizontal" - are illustrated in figure 6. (For data-recording purposes the positions are abbreviated "A," "V" and "H.") The three measurements, when compared with each other and/or with their previous values, can provide important clues as to type or magnitude of possible problems.

Methods for applying the pickup are listed below. Factors which may affect the accuracy (or desirability) of these methods are given immediately after the list, and should be studied carefully.

1. Hand held, with pickup end cap directly against vibrating part.
2. Hand held, with pickup probe against vibrating part, as shown in figure 6.

3. Attached to machine with vise grip holder or magnetic holder (optional pickup accessories) as shown in figure 7.

4. Installed on 1/4-28 stud welded on or threaded to machine part. See figure 7. (Mounting surface must be flat and stud square with surface to ensure good readings.)

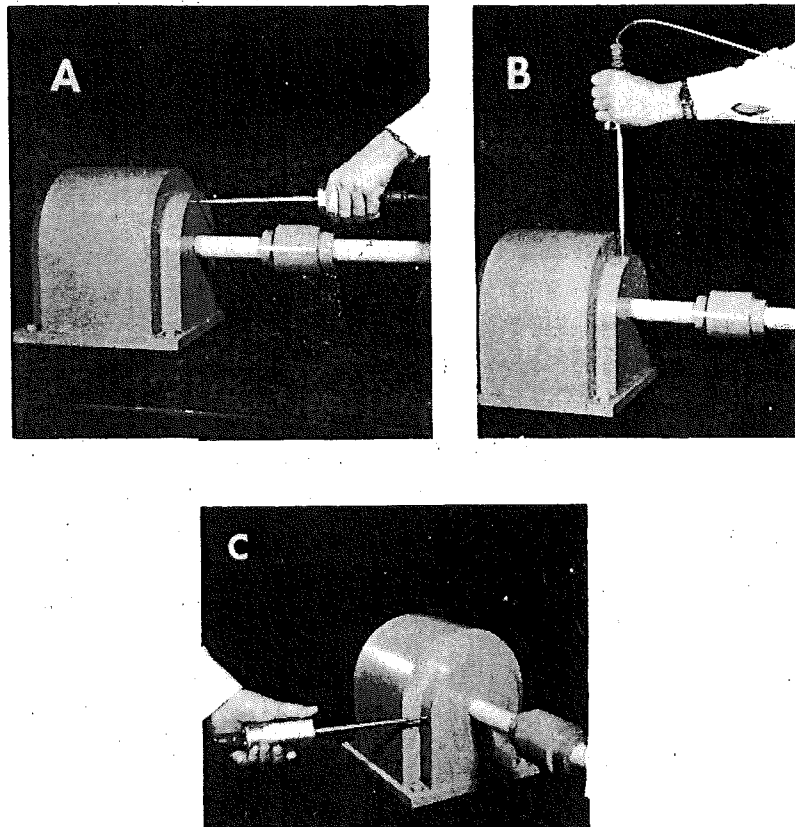
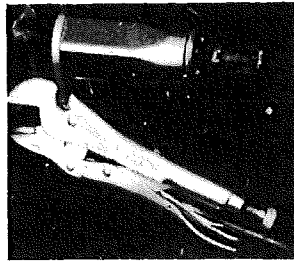
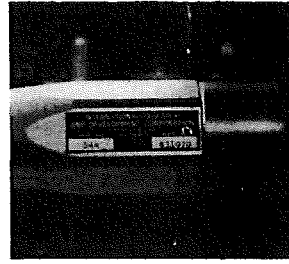


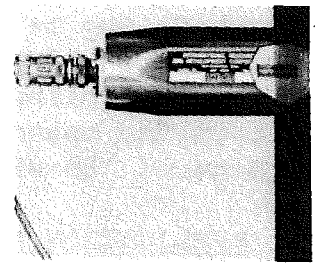
Figure 6. "Standard" Pickup Positioning



Vise Grip Holder



Magnetic Holder



Mounted on Stud

Figure 7. Applying Pickup for "Hands-free" Measurements

When hand-holding the pickup (with or without probe installed) use just enough force to prevent any chattering between the part and the pickup (or probe) - don't "lean" against the pickup. Keep the pickup as steady as possible while taking the meter reading.

Repeat measurements of a given point are taken to show any change in machine condition, by comparing the measurement values. When taking repeat measurements it is important to use the same relative pickup position each time, since a change in relative position can cause a change in the comparative measurements. To ensure "repeatability" when using methods 1, 2 or 3, make a practice of always placing the pickup in a reasonably true horizontal or vertical plane when conditions permit. If machine structure forces you to use an "unusual" pickup position, be sure to repeat that position for later measurements at the same point.

Methods 1 and 4 (hand held without probe, or stud mounted) may be used on machines or major machine components which operate at speeds of 720 to 60,000 RPM. The following methods are recommended only within the speed limits shown (due to "resonance" limits of the pickup accessories).

<u>APPLICATION METHOD</u>	<u>SPEED LIMITS</u>
Attached with vise grip holder	720 to 8,700 RPM
Hand held, with 9" probe	720 to 16,000 RPM
Attached with magnetic holder	720 to 37,000 RPM

MEASURING DISPLACEMENT

Vibration can be measured in terms of how far the part moves back and forth. This is called the peak-to-peak displacement or simply the displacement. The Model 308 measures this displacement in mils (or microns, Model 308M).

(1 mil = 0.001 inch; 1 micron = 1×10^{-6} meter.)

MEASURING VELOCITY

The Model 308 can also measure the vibration in terms of how fast the part moves. This is called the peak velocity and is measured in inches per second (or millimeters per second, Model 308M). Because velocity is a function of both displacement and frequency, it provides an added sensitivity to high frequency vibrations.

For instance, a vibration displacement of 0.1 mil (2.54 microns) results in the same meter reading when the frequency is 1800 CPM as it does at 18,000 CPM. The velocity for 0.1 mil at 1800 CPM is 0.0094 in/sec (0.239 mm/sec) but at 18,000 CPM the velocity is ten times as large or 0.094 in/sec (2.39 mm/sec). This means that small vibrations occurring at high frequency are easier to detect if velocity measurements are used. Since troubles such as bad bearings and gears cause vibration at high frequency, velocity measurements are extremely valuable.

VIBRATION TOLERANCES

Vibration measurements without a standard for comparison are seldom of any use. There must be some guide for determining how much is too much. Figure 8 provides a guide for Machine Tool vibrations.

TYPE OF MACHINE		Displacement of vibrations as read with pickup on spindle bearing housing in the direction of cut.	
Grinders		Tolerance Range *	
	Thread Grinder	.01	— .06 mils
	Profile or Contour Grinder	.03	— .08 mils
	Cylindrical Grinder	.03	— .10 mils
	Surface Grinder (vertical reading)	.03	— .2 mils
	Gardner or Bostly Type	.05	— .2 mils
	Centerless	.04	— .1 mil
Boring Machine		.06	— .1 mil
Lathe		.2	— 1.0 mils
1192 A	* 1 mil = 25.4 microns		

Figure 8. Guide to Machine Tool Tolerances

If machine tools vibrate beyond certain limits, the size or finish of the parts being machined will be unsatisfactory. The values listed indicate the range in which satisfactory parts have been produced. Actual tolerances must be determined by your own experience as to what vibration levels permit meeting size and finish tolerances.

For general types of machinery, the chart shown in figure 9 (or figure 10 if using Model 308M) may be used as a relative guide to how severe the vibration is. Of course, machine condition is considered to be progressively worse as severity increases from "Extremely Smooth" to "Very Rough." To interpret the severity when the machine vibration is measured in terms of displacement, the dominant (or principal) frequency of the vibration must be known. However, if the measurement is taken in terms of velocity, the severity can be read directly from the chart without knowing the dominant frequency. For example, a velocity reading of 0.1 in/sec (2.54 mm/sec) would indicate the severity (or condition) to be "Fair," regardless of the dominant frequency.

DETERMINING DOMINANT FREQUENCY

The Model 308 reads "overall" vibration. That is, if several vibrations (i.e., one at 1000 CPM, another at 2000 CPM, etc.) are present at the point being measured the meter reads the vector sum of all the vibrations. Usually one of these will be stronger (i.e., have more amplitude). This is the dominant vibration; knowing its frequency (or CPM) can tell us different things about the machine.

GENERAL MACHINERY VIBRATION SEVERITY CHART

For use as a GUIDE in judging vibration as a warning of impending trouble.

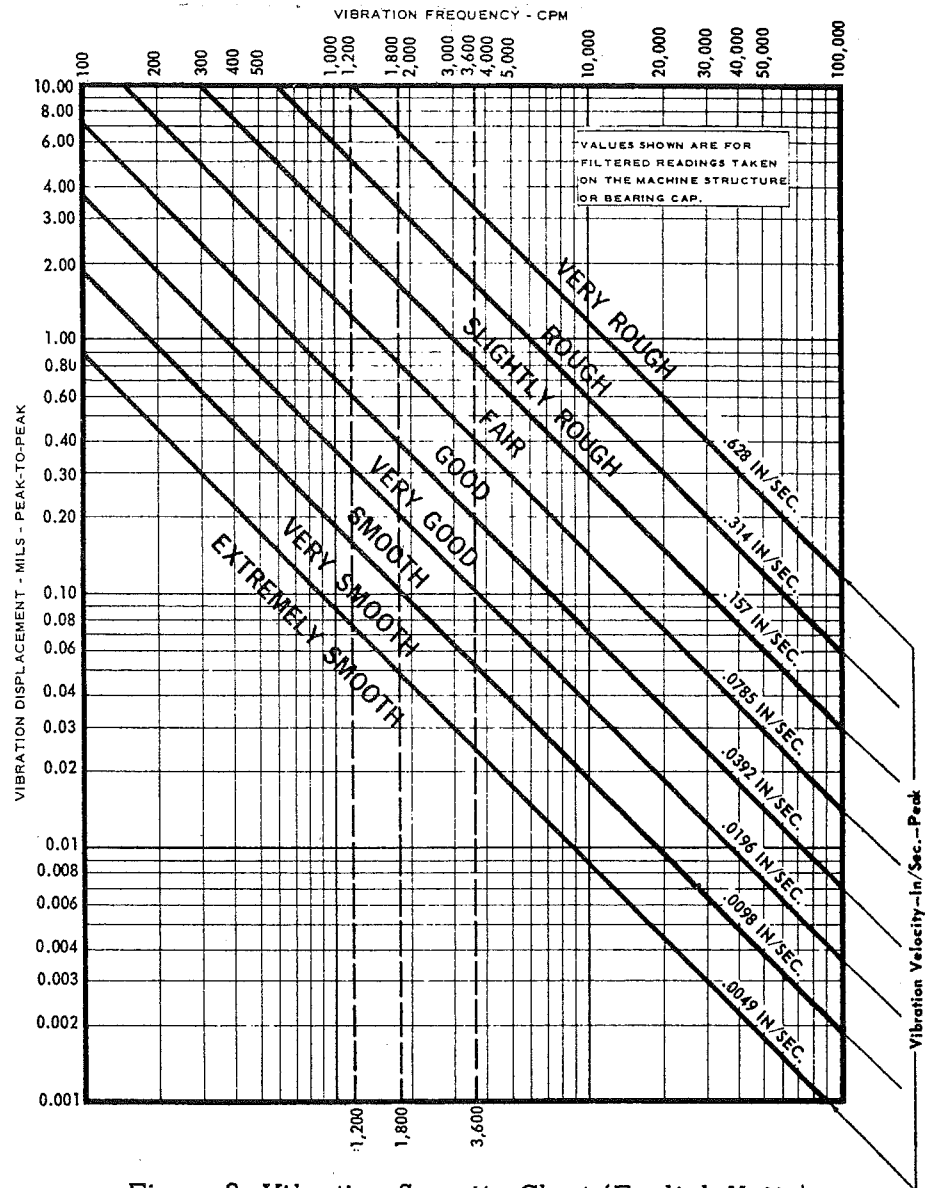


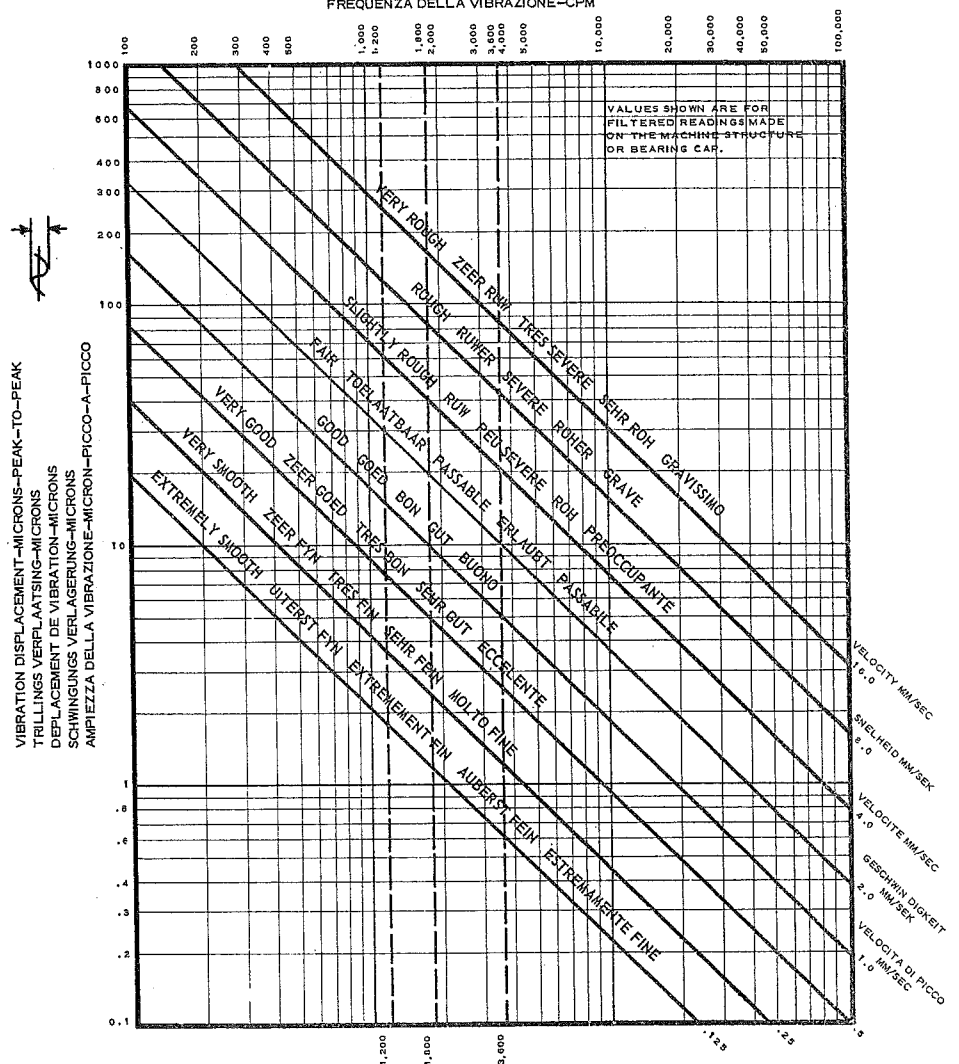
Figure 9. Vibration Severity Chart (English Units)



IRD-MECHANALYSIS INTERNATIONAL

GENERAL MACHINERY VIBRATION SEVERITY CHART
 TRILLINGS STRENGHEIDSKAART VOOR ALGEMENE MACHINES
 TABLEAU DE SEVERITE VIBRATOIRE POUR LES MACHINES EN GENERAL
 SCHWINGUNGSSTRENGE TABELLE FÜR ALLGEMEINE MASCHINEN
 NOMOGRAMMA GENERAL È DI PERICOLOSITÀ DELLA VIBRAZIONE

VIBRATION FREQUENCY-CPM
 TRILLINGS FREKVENTIE-CPM
 LES FREQUENCES DE VIBRATION-CPM
 SCHWINGUNG FREQUENZEN-CPM
 FREQUENZA DELLA VIBRAZIONE-CPM



The dominant frequency can be determined by taking both a velocity reading and a displacement reading at the same point with the Model 308 and then using the formula or chart solution described below.

CAUTION

- Although this method is in many cases a useful technique, use of a Vibration Analyzer is the preferred method for determining the specific vibration frequencies present.
- The dominant frequency cannot be accurately determined unless (1) both the VEL and DISP readings taken are very steady (i.e., the meter pointer does not change more than $\pm 5\%$ from the average value observed) and (2) the relative position of the pickup is not changed when taking the two readings.

Figure 11 is the chart solution, and can only be used if displacement and velocity are both in English units, or are both converted to English units.

The formula solution is:

$$\text{DOMINANT FREQUENCY (CPM)} = \frac{V}{D} \times 19,120$$

where V is velocity in in/sec (mm/sec) and D is displacement in mils (microns).

(The chart in figure 11 can only be used if dis-

placement and velocity are in English units, and the actual dominant frequency is between 500 and 10,000 CPM.)

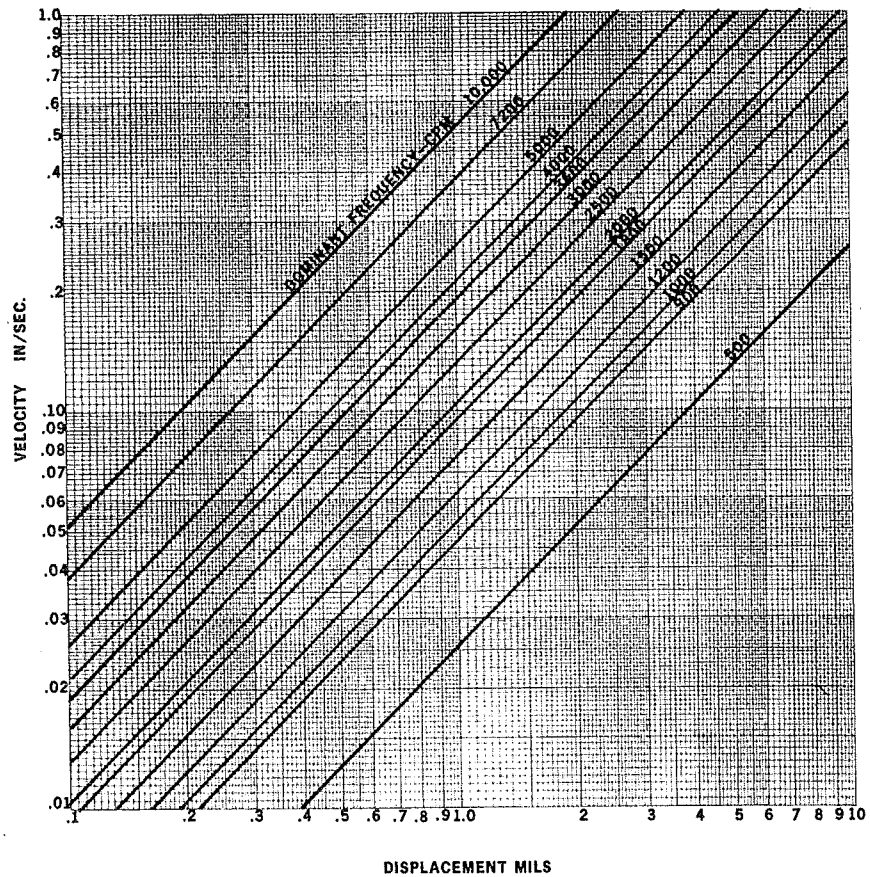
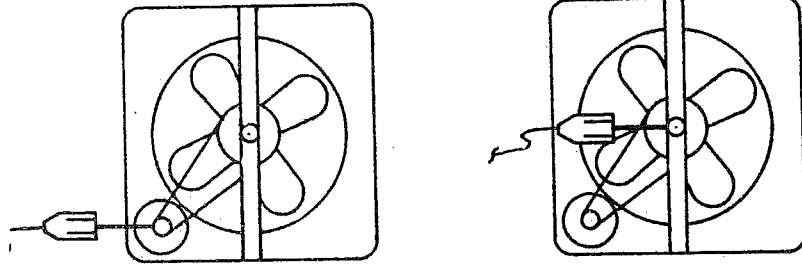


Figure 11. Chart for Determining Dominant Frequency

Significance of Dominant Frequency

Consider the belt-driven fan in figure 12. The motor and fan run at different speeds. The domi-



Measurements taken on motor contains vibrations of motor plus transmitted vibrations from the fan.

Measurements taken on fan contain vibrations of fan plus transmitted vibrations from the motor.

Figure 12. Transmission of Vibration

nant frequency will reveal which part of the machine is causing the most vibration. Measurements taken on the motor bearings would include vibrations of the motor plus vibrations from the fan transmitted through the drive belt and mounting structure. Conversely, measurements taken on the fan bearings would include vibrations of the fan plus vibrations transmitted from the motor. In many cases the point with the most vibration would pinpoint which part has the trouble, but not always. For example, structural design might cause the motor to vibrate more than the fan, even though the fan is the major cause of the vibration. To make a positive determination, the motor vibration is measured and found to have a displacement of $D = 1.85$ mils and a velocity of $V = 0.255$ inches per second. The dominant frequency is then calculated as:

$$\frac{0.255}{1.85} \times 19,120 = 2,649 \text{ CPM}$$

The motor and fan speeds are known to be 1,750 RPM and 2,600 RPM, respectively. From the calculation it can be concluded that the fan is the primary cause of the "overall" vibration measured at the motor. It can also be concluded that the cause of the fan vibration is probably unbalance, since unbalance of a rotating part causes a vibration frequency equal to its rotating speed. (It cannot, however, be concluded that only the fan is causing the vibration. After the fan is balanced, further measurements can indicate whether there is any significant trouble in the motor.)

Generally the dominant frequency will be equal to the rotating speed of the part causing the vibration, assuming that the trouble is unbalance. In any event the dominant vibration frequency will normally be some whole multiple of RPM of the part. After determining the dominant frequency, the type of trouble present may be assumed from the following:

DOMINANT
FREQUENCY

MOST LIKELY TROUBLES

1 x RPM

Unbalance and/or misalignment. If axial measurement value is 1/2 the value of the horizontal or vertical measurement, or larger, check for bent shaft or misalignment of couplings or bearings.

2 x RPM

Loose mounting or misalignment.

Use axial measurement to isolate, as stated above.

Many Times RPM Bad gears or bad roller or ball bearings.

There are many other causes of vibration not listed. To pinpoint all but the simplest requires a thorough analysis of the vibration using a Mechanalysis Vibration Analyzer.

VIBRATION MEASUREMENT APPLICATIONS

Preventive Maintenance

One of the most important applications of the Model 308 is making periodic vibration checks for preventive maintenance purposes.

The major phases of preventive maintenance are DETECTION, ANALYSIS, and CORRECTION. A measurable increase in the vibration of a machine is a symptom of wear or mechanical trouble. Periodic vibration measurements, recorded on a suitable data sheet such as shown in figure 13, provide the early DETECTION needed. Due to battery operation, size and simplicity of operation, the Model 308 is ideally suited for the DETECTION phase. The ANALYSIS phase pinpoints the cause of the trouble. Accurate vibration analysis requires the use of a Mechanalysis Vibration Analyzer/Dynamic Balancer. Once the problem is analyzed, CORRECTION can be scheduled for a convenient time; if unbalance is the problem, precise balancing can be achieved with the Analyzer/Balancer.

A primary requirement in setting up a preventive maintenance program is to initially establish the mechanical condition of each machine in the program. Although thorough measurements with the Model 308 can be of value, a true vibration analysis is best accomplished with an Analyzer/Balancer.

Note that the data sheet shown in figure 13 also includes provisions for recording periodic noise measurements. Noise measurements taken with the Model 308 can play an equally important role in

[illegible]

MACHINE: # 2 SSDG	
Component: DIESEL GENERATOR	
Location: ENGINE ROOM	
VIBRATION TOLERANCES ☐ DISP. ☒ VEL. A 0.157 D 0.314 B 0.157 E — C 0.314 F — NOISE TOLERANCES dB(A) QUADRANT— ① 90 dBA ② 90 " ③ 90 " ④ 90 "	

[illegible]

SOUND LEVEL MEASUREMENT
TECHNIQUES AND APPLICATIONS
SOME FUNDAMENTALS OF SOUND AND NOISE

Basic Characteristics of Sound

Defined in technical terms, sound is a pressure oscillation in a fluid (water, air, etc.), which moves radially away from the source which produces it. Sound radiates by, or is "propagated" by, wave motion through the fluid or "medium." The four characteristics of this wave motion are amplitude, frequency, velocity and wavelength.

The velocity of sound is essentially "fixed" by the medium in which it travels; e.g., in air, 1100 feet per second; in water, 4800 feet per second. (Velocity changes somewhat with temperature or pressure changes of the medium.) The wavelength (λ) is the distance between similar points on two adjacent "waves," and is determined both by the velocity (c) and the frequency (F) at which the waves are propagated, or:

$$\lambda \text{ (feet/cycle)} = \frac{c \text{ (feet/sec)}}{F \text{ (cycles/sec)}}$$

The frequency of sound is determined by the source causing it. One of the most common sources of sound is a vibrating solid (see figure 15). The vibrating or oscillating motion of the solid causes pressure changes (or oscillations) in the surrounding air, and hence the pressure oscillation (or sound) frequency is the same as the vibration frequency of the solid. If a number of individual

components of the machine shown in figure 15 are each vibrating at a different frequency, the "overall" sound radiating from the machine will contain an equal number of individual "pressure oscillation" (or sound) frequencies.

The amplitude of sound is determined by how much the medium is alternately compressed and rarefied during the pressure oscillations caused by the source. Stated in another way, the amplitude is a measure of the energy imparted to the medium by the source. The initial energy imparted to the medium dissipates with distance; hence, at any given point away from the source the amplitude is also a measure of the energy which can be imparted by the medium to a "receiver" (such as a microphone, or our ear).

Sound amplitude is measured with an instrument (or sensed by our ear) in terms of the pressure level changes (relative to the average or "atmospheric" pressure of the medium) that take place during the pressure oscillations. Hence, "sound amplitude" is more commonly called "Sound Pressure Level" (abbreviated SPL).

In addition to "sound pressure level," the term "sound level" is also commonly used in place of "sound amplitude." If sound is measured with an instrument that is fully responsive to all frequencies of sound, then the measured value will be in terms of "sound pressure level" - that is, it will measure what is actually "out there," or the true sound pressure level. For reasons explained later (see "How the Ear Hears") it is also desirable to measure sound with instruments designed to be fully responsive to some frequencies but less

responsive to others. Such instruments are usually called Sound Level Meters, and readings obtained with them are (or should be) called "sound level" readings; that is, they are not meant to measure in terms of actual "sound pressure level."

What is Noise?

The generally accepted definition of noise is simply "unwanted sound." This includes everything from the drip of a faucet in the middle of the night to the mighty roar of a moon rocket as it leaves the launch pad. It can even include music, if it interrupts the work of the listener. To be considered "noise," all that is required is that it be sound that is undesirable to the listener. In fact, in all of the preceding (or following) text, the word "noise" could be used to replace "sound" as long as the definition just given is applicable.

How Sound (or Noise) is Generated

Sound or noise can be generated in three ways. The most common of these is the vibrations of solid structures such as machines or wall panels which alternately compress and rarefy the air in contact with these structures. See figure 15. The rate or frequency at which these structures vibrate determines the frequency of the sound which is radiated. Thus, a 100 Hz (6000 cpm) vibration will generate a 100 Hz (6000 cpm) sound wave.

Sounds can also be generated by the movement of air over solid structures. A typical example is shown in figure 16. Even though the structure

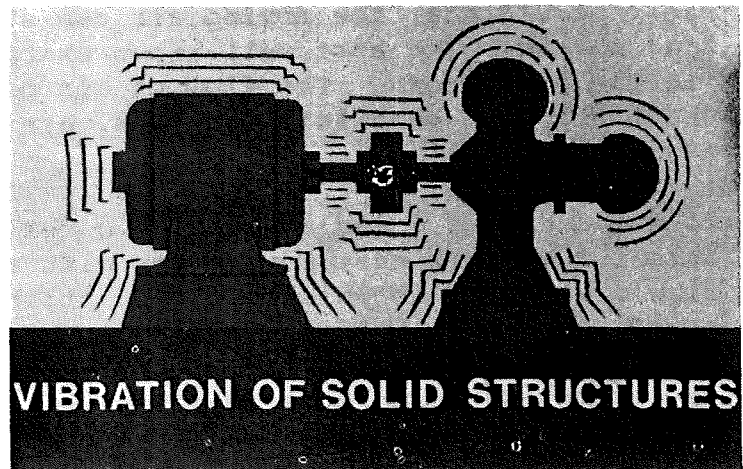


Figure 15. Most Common Source of Noise

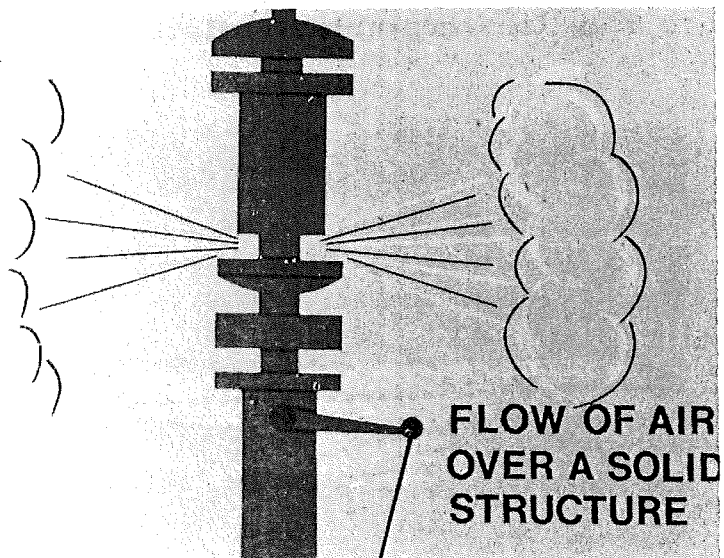


Figure 16. Air Moving Over Solid Structure Generates Noise

itself does not vibrate, the moving air can still create loud sounds. The most well-known example of this is the pipe organ. The flow of air over fan blades, or through ventilation grills, are other examples.

The third mechanism of sound generation comes from the turbulent mixing of fast moving air with relatively slow moving air in which no solid structures are involved. An example of this which is commonly heard is the noise from a jet engine. See figure 17. This type of sound only becomes important when the air (or gas) is moving at very high velocity.

All three of these sound generating mechanisms are commonly found in many types of industrial machinery; and by recognizing them, it is often possible to reduce them to acceptable levels.

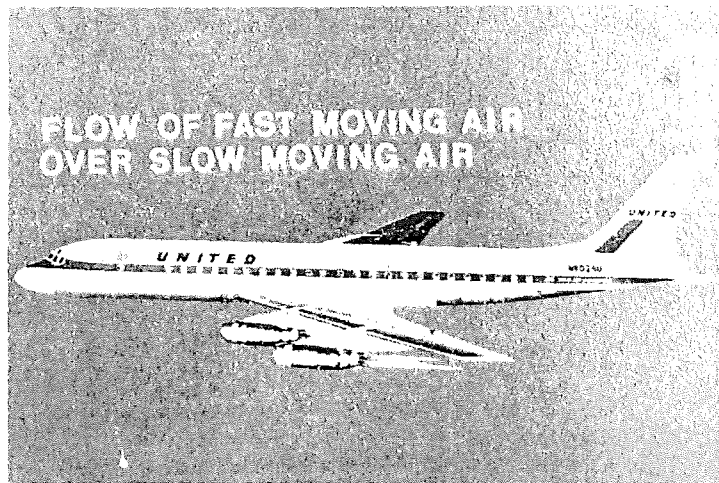


Figure 17. Fast-moving Air Mixed With Slow-moving Air Generates Noise

The Decibel

Sound, or noise, is measured in units called "decibels," which are abbreviated "dB." They are as easy to use as mils, microns, inches, or millimeters once you get a feel for them. The levels of a number of commonplace sources of noise are given in following paragraphs to provide this "feel."

From a technical standpoint, the decibel was selected because of the tremendous range of sound levels which the human ear can hear. Sound pressure levels of interest for engineering purposes cover a ratio of one billion to one ($10^9:1$). This made it very inconvenient to handle with conventional linear units such as lb./in.² (psi) or microbars. The decibel provides a logarithmic scale which compresses that huge linear range of one billion to one ($10^9:1$) into a decibel (logarithmic) range of only 180 to one (180:1).

Although it is not necessary to the understanding and measurement of noise, for those interested, sound pressure level is defined by the following equation:

Sound Pressure Level = SPL

$$SPL = 20 \log_{10} \frac{\text{Measured Sound Pressure (microbar)}}{\text{Reference Sound Pressure (microbar)}}$$

where Reference Sound Pressure = .0002 microbar (or 20 micronewtons per square meter).

Common Noise Sources and Levels

Figure 18 shows representative decibel levels encountered by people during the course of a day from common noise sources other than industrial.

Of course, these are only given as typical levels. Each of these sources can vary over a wide range depending upon a number of factors such as changing conditions at the "typical" source, the distance one is from the source, and the presence or absence of solid flat structures or surfaces which reflect the noise.

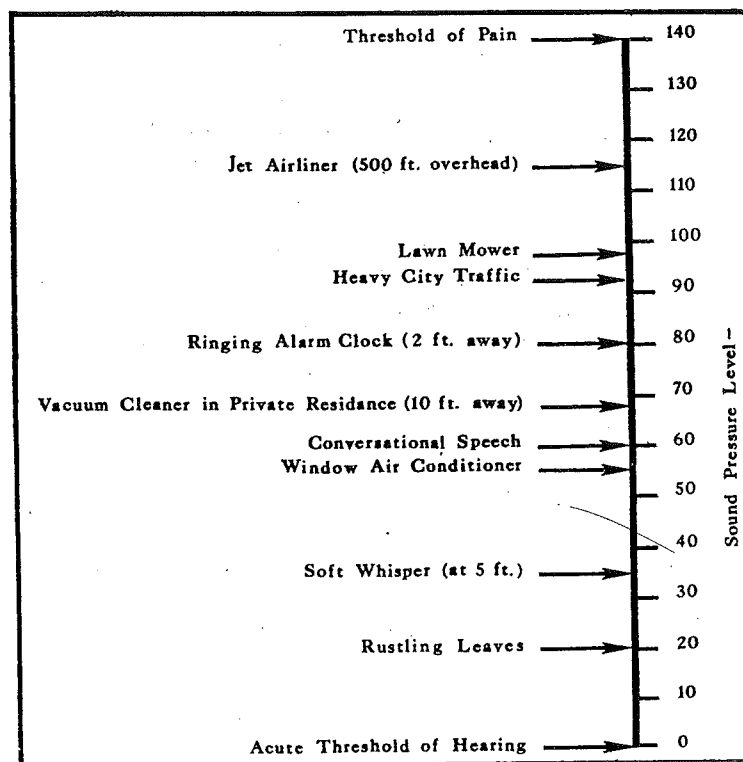


Figure 18. Common Non-Industrial Noise Levels

Industrial Noise

Noise generated by industry may be divided into two classes: those sources which affect the community around the industrial site, and those that affect the personnel on the site.

Large I. D. Fans, large transformers and high-pressure steam breakdown are examples of sources which can cause community noise problems. Diesel engines, compressors, chippers and grinders are a few of the sources which can affect personnel efficiency within a plant. Figure 19 provides examples of noise levels from industrial sources.

Acceptable Noise Levels for Different Working Areas

Numerous experimental studies have shown that workers' efficiency can be affected in varying degrees by noise. Tasks requiring a great deal of mental concentration and exactness are affected by noise to a significantly greater degree than others. For instance, even relatively moderate noises tend to dilate the pupils of the eyes, which results in a change in the eyes' focus. Thus, a watchmaker, and others who do close work, will experience difficulty in working where periodic loud noise is present.

In many cases the ability to verbally communicate is the governing criterion for acceptable noise levels. Here again, there is some variability; levels required for a conference room will differ from those required in a machine shop, or in the engine room of a ship.

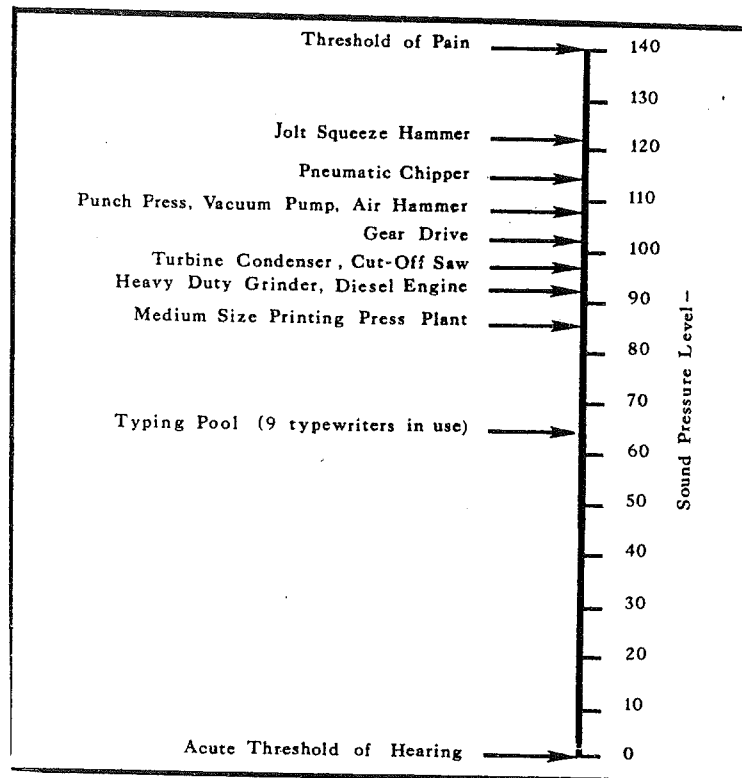


Figure 19. Typical Industrial Noise Levels

Where high noise levels occur in areas where work is less exacting and more routine, acceptability levels are governed by noise which can cause personnel fatigue and inefficiency. Figure 20 indicates some general guidelines on levels of acceptability for noise in different areas and conditions.

PARTS LIST

MAJOR ASSEMBLIES AND ACCESSORIES

PART NO.

Model 308 Vibration/Sound Level Meter	0068
Case, Carrying	9375
Instrument Assembly	9285
Microphone	5294
Vibration Pickup, Model 544	4526
Probe, Straight	1103
Cable Assembly, 4 foot	12433
Cable Assembly, 6-foot Retractable	9288
Strap, Leather	3829
Cap, ANALYZER Connector	9311
Plug, RECORDER Connector	9361
Operation and Maintenance Manual	9765

CIRCUIT COMPONENTS

Letters in Circuit Symbols in the components list have the following definitions:

B - Battery	M - Meter
C - Capacitor	P - Potentiometer
D - Diode	Q - Transistor
IC - Integrated Circuit	R - Resistor
J - Connector	S - Switch

CIRCUIT

SYMBOL

DESCRIPTION

PART

NO.

B1, B2	8.4V Mallory TR146X	9291
C1	6.8 uF 20 V	5396
C2	100 uF 12V	3605
C3	6.8 uF 20V	5396
C4	0.1 uF 80V	9342